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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

Application Number: 10/620,560
Filing Date: July 17, 2003
Appellant(s): LIAW ET AL.

Anthony Zelano and Jennifer Branigan
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed September 18, 2007 appealing from the Office action mailed November 15, 2006.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

EP 0618612A2	OHNISHI et al.	03-1994

(9) Grounds of Rejection

The following grounds of rejection are applicable to the appealed claims:

Claim Rejections - 35 USC § 102/103

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 13, 15, 16, 18-20, 24 and 25 are rejected under 35 U.S.C. 102(b) as being anticipated by Ohnishi et al. in EP 0618612A2 (hereinafter, Ohnishi) or, in the alternative, under 35 U.S.C. 103(a) as obvious over Ohnishi.

Ohnishi teaches a process whereby organic and inorganic sidewall residue is removed from a substrate after the plasma etching of the substrate through a patterned photoresist mask (figure 7a). Ohnishi teaches conducting a 5-10 minute cleaning process while the temperature is maintained between 80° and 130° C (column 8, lines 5-13). As a comparative example, Ohnishi teaches a cleaning solution comprising H_2SO_4, H_2O_2 and HF (column 7, lines 38-41). Additionally, Ohnishi teaches a cleaning solution comprising H_2SO_4, H_2O_2 and an HF generating compound, for example,

HSO_3F. Ohnishi teaches compositions wherein the concentration of HSO_3F ranges from 0.005% to 7.5%. This rejection is made in the 102/103 alternative for several reasons[1]. Except for the comparative example, Ohnishi does not teach adding HF directly to the solution. Rather, Ohnishi teaches providing a compound that generates HF in situ. Ohnishi does not expressly disclose the amount of HF that is produced in the solution. However, like appellant, Ohnishi teaches removing silicon dioxide and photoresist sidewall residue after the dry etching of a semiconductor wafer while not damaging the surface of the wafer. See figures 7(a) and 7(b). In view of the striking similarity between the results obtained from Ohnishi's and appellant's compositions, it is reasonable to conclude that these like results are obtained as a result of using like compositions. This, in part, prompted the rejection to be made in the 102/103 alternative because, "where the Patent Office has reason to believe that a functional limitation asserted to be critical for establishing novelty in the claimed subject matter may, in fact, be an inherent characteristic of the prior art, it possesses the authority to require the [appellant] to prove that the subject matter shown to be in the prior art does not possess the characteristic relied on".[2]

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[1] Example of circumstances when an alternative 102/103 rejections is appropriate:

a. When the reference discloses all the limitations of a claim except a property or function, and the examiner cannot determine whether or not the reference inherently possesses properties which anticipate or render obvious the claimed invention but has basis for shifting the burden of proof to applicant as in In re Fitzgerald, 619 F.2d 67, 205 USPQ 594 (CCPA 1980). See MPEP §§ 2112- 2112.02.

b. When the interpretation of the claims is or may be in dispute, i.e., given one interpretation, a rejection under 35 U.S.C. 102 is appropriate and given another interpretation, a rejection under 35 U.S.C. 103(a) is appropriate.

c. When the ranges disclosed in the reference and claimed by applicant overlap in scope but the reference does not contain a specific example within the claimed range. See the concurring opinion in Ex parte Lee, 31 USPQ2d 1105 (Bd. Pat. App. & Inter. 1993). See MPEP § 2131.03.

[2] In re Best, 562 F.2d 1252, 1255, 195 USPQ 430, 433-34 (CCPA 1977) at 1254-55, 195 USPQ at 433 (quoting from In re Swinehart, 58 CCPA 1027, 439 F.2d 210, 169 USPQ 226 (1971)).

The examiner notes that Ohnishi discloses providing fluorosulfonic acid, HSO_3F, to the composition in lieu of providing HF, while appellant's claims are directed to a composition "consisting essentially of" three components:

a) sulfuric acid;

b) hydrogen fluoride, ammonium fluoride or an alkali metal fluoride; and,

c) hydrogen peroxide.

To the extent that Ohnishi's HSO_3F embodiments even need to be relied upon, the examiner notes that Ohnishi discloses the following dynamic solution reactions:

$$HSO_3F + H_2O \rightleftarrows H_2SO_4 + HF$$

As such, Ohnishi's inclusion of HSO_3F is not at odds with the "consisting essentially of" language because <u>the above reaction dynamic reveals that appellant's composition, said to "consist essentially of" H_2O_2, H_2SO_4 and HF, actually contains the very same fluorosulfonic acid component that is provided by Ohnishi</u>. Because, HSO_3F is an inevitable component of appellant's compositions, the "consisting essentially of" claim language cannot be viewed as being exclusive of HSO_3F.

Most significant, however, is Ohnishi’s disclosed comparative example of “a solution formed by adding 1% hydrofluoric acid to a liquid mixture with a 5:1 ratio of sulfuric acid: hydrogen peroxide” (column 7, lines 38-41). Ohnishi's comparative example reads on the broadly recited H_2SO_4: HF ratio of 10:1 to 700:1 by weight, regardless of the interpretation one gives to Ohnishi’s recitation of, “a solution formed by adding 1% hydrofluoric acid to a liquid mixture with a 5:1 ratio of sulfuric acid: hydrogen peroxide”. Detailed calculations for various interpretations are includes in the calculations appendix. These calculations indicate a H_2SO_4: HF weight ratio ranging from about 75:1 to about 300:1. As such, Ohnishi's comparative example anticipates the H_2SO_4: H_2O_2 ratio recited in claim 13. It is additionally noted that appendix calculation a3) that shows a H_2SO_4: HF weight ratio of 225:1 also leads to a 3: 1 volume ratio between (H_2SO_4 + HF) and H_2O_2.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

Claims 14, 17, 21, and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ohnishi.

The above noted teachings of Ohnishi are herein relied upon.

Ohnishi does not teach:

1. the type of photoresist resist as being one of a g-line, i-line, Deep-UV, e-beam or X-ray;
2. removing photoresist while the operation pressure is maintained at 1 atm;
3. a (H_2SO_4 + HF): H_2O_2 ratio of 3:1.

It would have been obvious to one skilled in the art to apply the method of Ohnishi to one of a g-line, i-line, Deep-UV, e-beam or X-ray photoresist because Ohnishi is directed to the removal of a generic photoresist and the types of photoresist recited in claim 14 include the most common types of photoresist that were in use at the time of Ohnishi's disclosure.

It would have been obvious to one skilled in the art to carry out the method of Ohnishi while maintaining a pressure of 1 atm because when a reference is completely silent on a parameter such as pressure, the skilled artisan would assume that the ambient pressure is used. If Ohnishi intended the method to be carried out at anything other than 1 atm, one would expect this to be disclosed. In the absence of such a discloser it would be obvious to operate at a pressure of 1 atm.

It would have been obvious to one skilled in the art to optimize the process with regard to the ratio of the components in the cleaning solution because Ohnishi teaches that the composition ratio is a cause-effective variable.

"Normally, it is to be expected that a change in temperature, or in concentration, or in both, would be an unpatentable modification. Under some circumstances, however, changes such as these may impart patentability to a process if the particular ranges claimed produce a new and unexpected result which is different in kind and not merely degree from the results of the prior art... such ranges are termed "critical ranges and the applicant has the burden of proving such criticality... More particularly, where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation."[3]

Additionally, absent a showing of criticality[4], such concentration limitations are considered obvious.

(10) Response to Argument

Appellant asserts, claims 13, 15, 16, 18-20, 24 and 25 are not: (a) anticipated by Ohnishi or in the alternative, (b) are not obvious to one of ordinary skill in the art over Ohnishi.

Regarding the teaching of Ohnishi, as it relates to anticipation, appellant challenges the examiner's assertion that "similar results are obtained from Ohnishi's and [appellant's] compositions". Appellant calls attention to figure 3 of Ohnishi to argue:

> *"[t]he etching results for HF and HSO_3F ("fluorosulfuric acid") are <u>not</u> the same. They do not etch in the same manner."*

Additionally, appellant notes:

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[3] *In re Aller* 105 USPQ 233, 255 (CCPA 1955). See also *In re Waite* 77 USPQ 586 (CCPA 1948); *In re Scherl* 70 USPQ 204 (CCPA 1946); *In re Irmscher* 66 USPQ 314 (CCPA 1945); *In re Norman* 66 USPQ 308 (CCPA 1945); *In re Swenson* 56 USPQ 372 (CCPA 1942); *In re Sola* 25 USPQ 433 (CCPA 1935); *In re Dreyfus* 24 USPQ 52 (CCPA 1934).

[4] *Akzo v. E.I. du Pont de Nemours* 1 USPQ 2d 1704 (Fed. Cir. 1987)

> *"Ohnishi does not teach the amount of HF that is produced in solution and … the amount of HF generated cannot be determined."*

Furthermore, regarding the $HSO_3F + H_2O \leftrightarrows H_2SO_4 + HF$ reaction dynamic (referred to, by the examiner in the final Office action, by the commonly used term, "equilibrium"), appellant states:

> *"if the HF+ H_2SO_4 were in equilibrium with HSO_3F + H_20, the curves would be identical or at least parallel (due to differences in concentrations). As clearly depicted, this is not the case. Equilibrium is not reached and, thus, there is a difference between starting with HF and starting with HSO_3F. One skilled in the art could not conclude that a sufficiently high HF concentration could be reached when starting from HSO_3F."*

In response, the examiner notes the following:

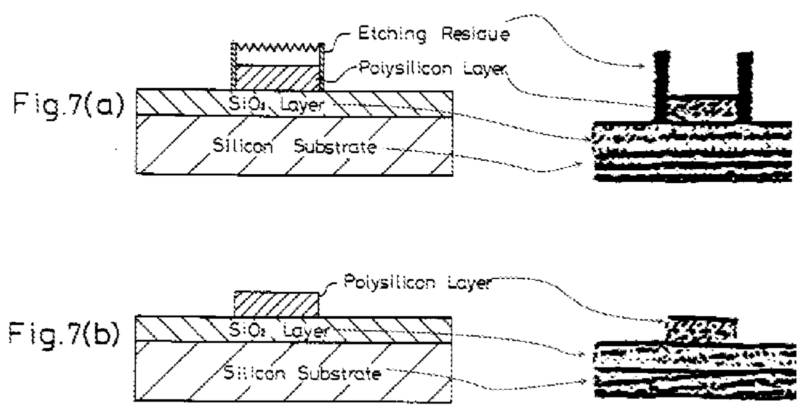
- Figure 3, upon which appellant relies, depicts data for the "solution formed by adding 1% hydrofluoric acid to a liquid mixture with a 5:1 ratio of sulfuric acid: hydrogen peroxide". As noted in the above rejection, this is a composition that outright anticipates appellant's claim 13 without reliance on Ohnishi's fluorosulfonic acid embodiments.

- To the extent that it matters, figure 3 depicts as much similarity between HF and HSO_3F as it depicts differences. It is essential to realize that <u>the line representing the HSO_3F data is generated from only **two** data points</u>. At time = 0, the data points for HSO_3F and HF differ. However, at time = 1 hour, the two points have <u>converged</u>, that is to say the <u>etching result for HSO_3F is identical to the result from HF</u> at the 1 hour mark. Furthermore, the extrapolation of the HSO_3F line beyond the 1 hour time marker represents pure (and dubious) speculation. Given the above noted $HSO_3F + H_2O \leftrightarrows H_2SO_4 + HF$ reaction dynamic, it is reasonable to expect an extrapolated HSO_3F line to tail off and become coincident with the HF line. As shown at the 1 hour mark, and as stated by appellant, *if the HF+ H_2SO_4 were in equilibrium with HSO_3F + H_20, the curves would be identical or at least parallel.*

- Regarding the examiner’s contention that appellant and Ohnishi achieve comparable results, the examiner notes the following:

    - as shown below, figures 7(a) and 7(b) of Ohnishi depict the same advantage over the prior art that appellant’s show in their figures 2 and 3.

Ohnishi Figure 7(a) - prior art | **detail appellant's figure 2 - prior art**



Ohnishi Fig. 7(b) - H2SO4 + H2O2 + HF generating HSO3F | **detail appellant's figure 3 - H2SO4 + H2O2 + HF**

    - Ohnishi teaches a 10 minute cleaning treatment at a temperature of preferably between 80° and 130°C to remove etching residue from a semiconductor wafer without damaging the wafer's surface, whereas appellant claims a 10 minute cleaning treatment and a temperature of between 0° and 130°C, or between 120° and 140°C, to remove etching residue from a semiconductor wafer without etching the wafer at rate greater than or equal to 1 Å/ min (i.e., “without damaging the wafer’s surface”).

Appellant next addresses the examiner's reliance on *In re Best* to require appellant to prove that the subject matter shown to be in the prior art does not possess the characteristic relied upon. Appellant argues, that before that PTO can impose such a requirement, the PTO must show that it is reasonable to believe that the prior art does indeed possess the characteristic relied upon.

Again, the examiner relies upon the following facts to show that it is reasonable to believe that Ohnishi does indeed possess the claimed H_2SO_4: HF ratio:

1. Ohnishi obtains results that are strikingly similar to applicant's results
2. Ohnishi's results are obtained from a solution "consisting of" H_2SO_4, H_2O_2 and HSO_3F.
3. Ohnishi provides HSO_3F to generate HF via the following:

$$HSO_3F + H_2O \rightleftarrows H_2SO_4 + HF$$

4. After 1 hour, HSO_3F results = HF results

Appellant argues the examiner is unjustified in concluding that Ohnishi's solution, formed by adding 1% hydrofluoric acid to a liquid mixture with a 5:1 ratio of sulfuric acid : hydrogen peroxide, corresponds to a 300:1 H_2SO_4 :HF ratio because "the teachings of Ohnishi are so ambiguous". Appellant argues:

> *"[i]n order to determine if the comparative example satisfies the ratio of a:b in the claims, one would first have to know if the reference is teaching 1% of a standard 49% HF solution, a 1% HF solution or a 1% concentration of HF in the final solution. It cannot be determined whether the components of Ohnishi's solution are weight, volume or mole amounts."*

Lastly, appellant argues:

> *"there is no way to know the ratio of HF to H_2SO_4. Without knowing how much of the 1% HF solution was added to the H_2SO_4:H_20_2 mixture it is impossible to know the final amount of HF in Ohnishi's comparative example. Ohnishi is not only ambiguous with regards to weight, volume or mole percentage ratios but is ambiguous with regards to the amount of 1%HF solution that was added to the H_2SO_4:H_20_2 mixture."*

The examiner notes that this last argument is based upon the notion that Ohnishi is adding an unknown volume of a 1% solution of HF to the H_2SO_4/H_2O_2 mixture. In so doing, appellant has selected the one interpretation of Ohnishi that inevitably suggests Ohnishi's disclosure is inadequate. Alternatively, one can interpret Ohnishi's "adding 1% hydrofluoric acid to a liquid mixture" to mean the final sowill have an HF concentration of 1%. By this reading, Ohnishi does provide a sufficient disclosure to replicate the solutions – regardless of whether one uses weight, volume or mole ratios. As patent documents are generally required to enable one skilled in the art to replicate the disclosed invention, it is reasonable to select the interpretation of Ohnishi that enables the process. Stated a little differently, when the prior art can be interpreted in two ways, with one interpration being enabling while the other is not, it would be obvious for one skilled in the art to adopt the enabling interpretation because that is the only choice that would allow the skilled artisan to proceed.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

/Allan Olsen/
Primary Examiner, Art Unit 1792

Conferees: /Parviz Hassanzadeh/
SPE, AU 1792

/Romulo Delmendo/
Romulo Delmendo

Appendix: Calculations

Standard Concentrations of concentrated solutions (weight percent):

H_2SO_4 = 96% H_2O_2 = 30% HF = 49%

Densities:

H_2SO_4 = 1.84 g/ml; HF = 1.16 g/ml; H_2O_2 = 1.13 g/ml

Density of 5:1 H_2SO_4: H_2O_2 = 1.72 g/ml (weighted average)

1% HF in 5:1 H_2SO_4 : H_2O_2

Calculations follow for each of:

A) Volume percent of concentrated HF solution

a1) 1% by volume of concentrated HF in solution that is 5:1 by volume of H_2SO_4: H_2O_2
a2) 1% by volume of concentrated HF in solution that is 5:1 by weight of H_2SO_4: H_2O_2
a3) 1% by volume of concentrated HF in solution with a 5:1 mole ratio of H_2SO_4: H_2O_2

B) Weight percent of concentrated HF solution

weight/weight (w/w) (e.g., 1g solute/100 g solution)

weight/volume (w/v) (e.g., 1g solute/100 ml solution)

b1) 1% concentrated HF (w/w) in a solution that is 5:1 by volume of H_2SO_4: H_2O_2
b2) 1% concentrated HF (w/w) in a solution that is 5:1 by weight of H_2SO_4: H_2O_2
b3) 1% concentrated HF (w/w) in a solution with a 5:1 mole ratio of H_2SO_4: H_2O_2
b4) 1% concentrated HF (w/v) in solution that is 5:1 by volume of H_2SO_4: H_2O_2
b5) 1% concentrated HF (w/v) in solution that is 5:1 by weight of H_2SO_4: H_2O_2
b6) 1% concentrated HF (w/v) in solution with a 5:1 mole ratio of H_2SO_4: H_2O_2

C) Weight percent of hydrogen fluoride molecule (rather than the aqueous acid solution)

c1) 1% HF (w/w) in a solution that is 5:1 by volume of H_2SO_4: H_2O_2
c2) 1% HF (w/w) in a solution that is 5:1 by weight of H_2SO_4: H_2O_2
c3) 1% HF (w/w) in a solution with a 5:1 mole ratio of H_2SO_4: H_2O_2
c4) 1% HF (w/v) in a solution that is 5:1 by volume of H_2SO_4: H_2O_2
c5) 1% HF (w/v) in a solution that is 5:1 by weight of H_2SO_4: H_2O_2
c6) 1% HF (w/v) in a solution with a 5:1 mole ratio of H_2SO_4: H_2O_2

A) Volume percent of concentrated HF solution

a1) 1% by volume of concentrated HF in solution that is 5:1 by volume of H_2SO_4: H_2O_2

1ml of 49% HF + 99 ml of 5:1 by volume of H_2SO_4: H_2O_2

99 ml of 5:1 by volume of H_2SO_4: H_2O_2 = 82.5 ml H_2SO_4 + 16.5 ml H_2O_2

1ml HF + 82.5 ml H_2SO_4 + 16.5 ml H_2O_2

1 ml of 49% HF * (1.16 g/ml) = 1.16 g of 49% HF

49% of 1.16 g = **0.57 g HF**

82.5 ml H_2SO_4 * (1.84 g/ml) = 152g of 96% H_2SO_4 = **146 g H_2SO_4**

146g H_2SO_4: 0.57 g HF

H_2SO_4: HF

256: 1 weight ratio reads on claim 1.

a2) 1% by volume of concentrated HF in solution that is 5:1 by weight H_2SO_4: H_2O_2

1ml of 49% HF in 99 ml of 5:1 by weight of H_2SO_4: H_2O_2

99 ml of 5:1 w/w of H_2SO_4: H_2O_2*(1.72 g/ml) =170.28 g of 5:1 by weight H_2SO_4: H_2O_2

170.28*(5/6) = 142 g H_2SO_4 of 96% H_2SO_4 = **136 g H_2SO_4**

1 ml of 49% HF * (1.16 g/ml) = 1.16 g of 49% HF

49% of 1.16 g = **0.57 g HF**

136 g H_2SO_4: 0.57 g HF

239 H_2SO_4: 1 HF weight ratio

H_2SO_4: HF

239: 1 weight ratio reads on claim 1.

a3) 1% by volume of concentrated HF in solution with 5:1 mole ratio of H_2SO_4: H_2O_2

<u>1 ml of 49% HF</u> * in 99 ml of 5:1 mole ratio of H_2SO_4: H_2O_2

99 ml = (*<u>72.5 ml H_2SO_4</u>* + *<u>26.5 ml H_2O_2)*</u>*

(* see calculation regarding claim 21 below)

To verify the 5:1 molar ratio,

72.5 ml H_2SO_4 (1.84 g/ml) = 133.4 g of 96% H_2SO_4 = **128 g H_2SO_4**

128 g H_2SO_4 (1 mol/98 g) = 1.31 mol H_2SO_4

26.5 ml H_2O_2 (1.1 g/ml) = 29.2 g of 30% H_2O_2 = 8.75 g H_2O_2

8.75 g H_2O_2 (1 mol/34 g) = 0.257 mol H_2O_2

1.31 mol H_2SO_4: 0.257 mol H_2O_2 = 5 moles H_2SO_4: 1 mole H_2O_2

1 ml 49% HF * (1.16 g/ml) = 1.16 g of 49% HF = **0.57 g HF**

128 g H_2SO_4 : 0.57 g HF

H_2SO_4: HF

225: 1 weight ratio reads on claim 1.

* <u>Regarding Claim 21</u>:

(1 ml HF + 72.5 ml H_2SO_4): 26.5 ml H_2O_2

73.5/26.5: 26.5/26.5 = 2.8: 1 ~ **3: 1**

B) Weight percent of Concentrated HF

b1) 1% w/w of 49% HF in a 5:1 by volume H_2SO_4: H_2O_2

1% (w/w) of 49% HF = 1 g 49% HF in 99 g of 5:1 by volume of H_2SO_4: H_2O_2

99 g of 5:1 by volume of H_2SO_4: H_2O_2 (1 ml/1.72 g) = 57.7 ml of 5:1 H_2SO_4: H_2O_2

5/6 of a 5:1 H_2SO_4:H_2O_2 solution is H_2SO_4, so,

(5/6)* 57.7 ml of 5:1 by volume H_2SO_4: H_2O_2 = 48.1 ml H_2SO_4 of 96% H_2SO_4

48.1 ml (1.84 g/ml) = 86.5 g 96 % H_2SO_4 = **83.0 g H_2SO_4**

1 g of 49% HF = **.49 g of HF**

83.0 g H_2SO_4: .49 g HF

H_2SO_4: HF

169.5: 1 weight ratio reads on claim 1.

b2) 1% w/w of concentrated HF in solution that is 5:1 by weight H_2SO_4: H_2O_2

1 g of 49% HF in 99 g of 5:1 by weight H_2SO_4: H_2O_2

99 g of 5:1 w/w of H_2SO_4: H_2O_2

(5/6)*99 g of 5:1 w/w of H_2SO_4: H_2O_2 = 82.5 g H_2SO_4 of 96% H_2SO_4 = **79.2 g H_2SO_4**

1 g of 49% HF = **.49 g HF**

79.2 g H_2SO_4 : 0.49 g HF

162 H_2SO_4 : 1 HF weight ratio

H_2SO_4: HF

162: 1 weight ratio reads on claim 1.

b3) 1% (w/w) of concentrated HF in solution with 5:1 mole ratio of H_2SO_4: H_2O_2

1g of 49% HF in 99 g of 5:1 mole ratio of H_2SO_4: H_2O_2

81 g H_2SO_4 + 18 g H_2O_2 = 99 g with 5:1 molar ratio.

To verify the 5:1 molar ratio between H_2SO_4 and H_2O_2

81 g of 96% H_2SO_4 = 77.8 g H_2SO_4 *(1 mol/ 98 g) = .793 mol H_2SO_4

18 g of 30% H_2O_2 = 5.4 g H_2O_2 *(1 mol/34 g) = .159 mol H_2O_2

.793 mol H_2SO_4: .159 mol H_2O_2

5:1

81 g of 96% H_2SO_4: 1g of 49% HF

77.8 g H_2SO_4: 0.49 g HF

H_2SO_4: HF

159: 1 weight ratio reads on claim 1.

b4) 1% (w/v) of 49% HF in a 5:1 by volume H_2SO_4: H_2O_2

1% (w/v) = 1 g solute/100 ml solution)

1 g 49% HF (1ml/1.16 g) = .86 ml

Therefore, need 99.14 ml of 5:1 by volume of H_2SO_4: H_2O_2

99.15 ml of 5:1 by volume of H_2SO_4: H_2O_2 *(5/6) = 82.6 ml H_2SO_4

82.6 ml (1.84 g/ml) = 152 g 96 % H_2SO_4 = **146 g H_2SO_4**

1 g of 49% HF = **.49 g of HF**

146 g H_2SO_4: .49 g HF

H_2SO_4: HF

298: 1 weight ratio reads on claim 1.

b5) 1% w/v of concentrated HF in solution that is 5:1 by weight H_2SO_4: H_2O_2

1% w/v = 1 g solute /100 ml solution

1 g 49% HF (1ml/1.16 g) = .86 ml

Therefore, need 99.14 ml of 5:1 by weight of H_2SO_4: H_2O_2

99.14 ml * (1 .72 g/ml) = 170 g

170 g * (5/6) = 142 g of 96 % H_2SO_4 = **136 g H_2SO_4**

1 g of 49% HF = **.49 g HF**

136 g H_2SO_4 : 0.49 g HF

H_2SO_4: HF

278: 1 weight ratio reads on claim 1.

b6) 1% (w/v) of concentrated HF in solution with 5:1 mole ratio of H_2SO_4: H_2O_2

1% w/v = 1 g solute /100 ml solution

1 g 49% HF (1ml/1.16 g) = .86 ml

Therefore, need 99.14 ml of 5:1 mole ratio of H_2SO_4: H_2O_2

99.14 ml = 72.5 ml H_2SO_4 + 26.6 ml H_2O_2

To verify the 5:1 mole ratio,

72.5 ml H_2SO_4 (1.84 g/ml) = 133.4 g of 96% H_2SO_4 = 128 g H_2SO_4

128 g H_2SO_4 (1 mol/98 g) = 1.31 mol H_2SO_4

26.6 ml H_2O_2 (1.1 g/ml) = 29.2 g of 30% H_2O_2 = 8.78 g H_2O_2

8.78 g H_2O_2 (1 mol/34 g) = 0.258 mol H_2O_2

1.31 mol H_2SO_4: 0.258 mol H_2O_2

5 moles H_2SO_4: 1 mole H_2O_2

1g of 49% HF = **0.49 g HF**

128 g H_2SO_4: 0.49 g HF

H_2SO_4: HF

261:1 weight ratio reads on claim 1.

C) Weight percent of hydrogen fluoride molecule (rather than of the aqueous solution)

c1) 1% HF (w/w) in a solution that is 5:1 by volume of H_2SO_4: H_2O_2

1% HF (w/w) = 1g HF/ 100 g of solution

1 g HF = 2 g of 49% HF

98 g of 5:1 by volume of H_2SO_4: H_2O_2

98 g * (1 ml/1.72 g) = 56.98 ml

(5/6) * 56.98 = 47.48 ml H_2SO_4

47.48 ml H_2SO_4 * (1.84 g/ml) = **87.36 g H_2SO_4**

H_2SO_4: HF

87: 1 weight ratio reads on claim 1.

c2) 1% HF (w/w) in a solution that is 5:1 by weight of H_2SO_4: H_2O_2

1% HF (w/w) = 1g HF/ 100 g of solution

1 g HF = 2 g of 49% HF

98 g of 5:1 by weight of H_2SO_4: H_2O_2

(5/6) * 98 g = **81.67 g H_2SO_4**

81.7 g H_2SO_4: 1 g HF

H_2SO_4: HF

82: 1 weight ratio reads on claim 1.

c3) 1% HF (w/w) in a solution with a 5:1 mole ratio of H_2SO_4: H_2O_2

1% (w/w) HF = 1g HF in 100 g of solution

1g HF = 2g of 49% HF

98 g of 5:1 mole ratio of H_2SO_4: H_2O_2

80.2 g of H_2SO_4 + 17.8 g H_2O_2 = 98 g of 5:1 mole ratio of H_2SO_4: H_2O_2

To verify the 5:1 molar ratio,

80.2 g of 96% H_2SO_4 = **77.0 g H_2SO_4**

77.0 g H_2SO_4 * (1 mol/98 g) = 0.786 moles of H_2SO_4

17.8 g of 30% H_2O_2 = 5.34 g H_2O_2

5.34 g H_2O_2 * (1 mol/34 g) = 0.157 moles of H_2O_2

0.786 moles of H_2SO_4: 0.157 moles of H_2O_2 = 5: 1 mole ratio

77g H_2SO_4: 1 g HF

H_2SO_4: HF

77: 1 weight ratio reads on claim 1.

c4) 1% (w/v) of hydrogen fluoride in a 5:1 by volume H_2SO_4: H_2O_2

1% (w/v) = 1 g solute/100 ml solution)

1 g HF = 2 g of 49% HF

2 g of 49% HF * (1 ml/1.16 g) = 1.72 ml of 49 % HF

1.72 ml of 49 % HF + 98.28 ml of 5:1 by volume H_2SO_4: H_2O_2 = 100 ml total solution

98.28 ml of 5:1 by volume H_2SO_4: H_2O_2

(5/6) * 98.28 ml of 5:1 by volume H_2SO_4: H_2O_2 = 81.9 ml of 96 % H_2SO_4

81.9 ml * (1.84 g/ml) = 150.7 g 96 % H_2SO_4

150.7 g of 96 % H_2SO_4 = **144.7 g H_2SO_4**

145 g H_2SO_4: 1g HF

H_2SO_4: HF

145: 1 weight ratio reads on claim 1.

c5) 1% w/v of hydrogen fluoride in solution that is 5:1 by weight H_2SO_4: H_2O_2

1% (w/v) = 1 g solute/100 ml solution)

1 g HF = 2 g of 49% HF

2 g of 49% HF * (1 ml/1.16 g) = 1.72 ml of 49% HF

1.72 ml of 49 % HF + 98.28 ml of 5:1 by weight H_2SO_4: H_2O_2 = 100 ml total solution

98.28 ml of 5:1 by weight H_2SO_4: H_2O_2

98.28 ml * (1 .72 g/ml) = 169 g of 5:1 by weight H_2SO_4: H_2O_2

169 g * (5/6) = 140.9 g of 96 % H_2SO_4 = **135 g H_2SO_4**

135 g H_2SO_4 : 1 g HF

H_2SO_4: HF

135: 1 weight ratio reads on claim 1.

c6) 1% (w/v) of concentrated HF in solution with 5:1 mole ratio of H_2SO_4: H_2O_2

1% w/v = 1 g solute /100 ml solution

1 g HF = 2 g of 49% HF

2 g of 49% HF * (1 ml/1.16 g) = 1.72 ml of 49% HF

1.72 ml of 49% HF + 98.28 ml of 5:1 H_2SO_4: H_2O_2 mole ratio = 100 ml total solution

71.66 ml of 96% H_2SO_4 + 26.62 ml of 30% H_2O_2 = 98.28 ml with 5:1 molar ratio

To verify the 5:1 mole ratio,

71.66 ml H_2SO_4 (1.84 g/ml) = 131.9 g of 96% H_2SO_4 = 126.6 g H_2SO_4

126.6 g H_2SO_4 (1 mol/98 g) = 1.29 mol H_2SO_4

26.62 ml H_2O_2 (1.1 g/ml) = 29.3 g of 30% H_2O_2 = 8.78 g H_2O_2

8.78 g H_2O_2 (1 mol/34 g) = 0.258 mol H_2O_2

1.29 mol H_2SO_4: 0.258 mol H_2O_2

5 moles H_2SO_4: 1 mole H_2O_2

126.6 g H_2SO_4: 1 g HF

H_2SO_4: HF

127:1 weight ratio reads on claim 1.